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On False Education

With the author's compts

BY

FREDERICK HOVENDEN,
F.L.S., F.G.S., F.R.M.S.,
Fellow of the Physical Society of London

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"'Then upon this side I make de table of de moon, which is a square of nine, multiplied into itself, with eighty-one numbers on every side, and diameter nine—dere it is done very proper. Now I will make dis avail me at de change of every quarter-moon dat I shall find by de same proportions of expenses I lay out in de suffumigations, as nine, to de product of nine multiplied into itself.'.....'But, Dousterswivel,' said the simple Baronet, 'does not this look like magic?'.....'Bah! bah!—not a bit magic in it at all—not a bit—It is all founded on de planetary influence, and de sympathy and force of numbers.'"—THE ANTIQUARY.

PROBABLY it is not too much to say that eighty per cent. of human suffering and misery, in all classes of society, arises from ignorance, and especially from that most terrible form of ignorance, educated ignorance—*i.e.*, false education.

There can be no doubt that all chemical and biological (*i.e.*, life) phenomena are physical phenomena—that is to say, the grouping of sub-atoms, atoms, and molecules; also their motions. Hence the interpreter of Nature, the physicist, should be the high priest of knowledge.

Unfortunately, the minds of physicists have been warped and stultified by the educational world—that is to say, by means of a metaphysical order of thought derived from the ancients which is physically impossible in Nature—*i.e.*, absurd mathematics. Physicists have never asked themselves what this order of thought means, but have simply followed each other like a flock of sheep taking a wrong path.

The object of this essay is to expose the absurdities of this mathematical order of thought and to substitute for it a rational one.

During the past ten years efforts have been made to expose this fundamental error, and now physicists and mathematicians are beginning to see the mistake. This fact is shown especially in the President's (Professor Horace Lamb) address to the mathematical and physical section at the British Association, 1904, delivered at that most remarkable place in the world for such an address—Cambridge. This address was a most complete condemnation of the exclusive tendency to subordinate the mind to mere figures and symbols. The President said :—

> "The traditional kind of education given to our professed mathematical students does not tend to its most effectual cultivation. This education is apt to be one-sided, and too much divorced from the study of tangible things." "The investigators of the classical school, as it may perhaps be styled, were animated by a simple and vigorous faith; they sought as a matter of course for a mechanical explanation of phenomena, and had no misgivings as to the trustiness of the analytical weapons which they wielded. But now the physicist and the mathematician alike are in trouble about their souls."[1] "Modern analysts have discovered, however, that Geometry may be a snare as well as a guide." "It is now sought to establish the whole fabric of mathematical analysis on a strictly arithmetical basis. To those who were trained in an earlier school, the results so far are in appearance somewhat forbidding." "The conception of the physical world as a mechanism, constructed on a rigid mathematical plan, whose most intimate details might possibly some day be guessed, was, I think, somewhat depressing. We

[1] Witness the following wail from a prominent physicist and mathematician: "It is surely an awful thing that many earnest men, because they have faith in us, should be induced to spend years in making ropes of sand.....The nation feels that its common sense has been outraged, and it is not merely elementary education that is going into the melting pot" *(Professor J. Perry, F.R.S.)*.

have been led to recognise that the formal and mathematical element is of our own introduction; that it is merely the apparatus by which we map out our knowledge, and has no more objective reality than the circles of latitude and longitude on the sun." "We have discussions on the principles of mechanics, on the foundations of geometry, on the logic of the most rudimentary arithmetical processes, as well as of the more artificial operations of the Calculus. These discussions are legitimate and inevitable, and have led to some results which are now widely accepted."

We must remember that this is stated from authority, and comes from the mathematical and physical world. Such is the present phase of advanced thinkers as regards the mathematical order of thought!

How is it that all this confusion exists? The answer is very simple. Mathematics can be divided into two distinct divisions: Common-sense mathematics—*i.e.*, arithmetic; and metaphysical or mentally diseased mathematics, rising upwards from and including algebra. The fundamental error arises in this way: Arithmetic recognises three factors only—namely, position, addition to position, and subtraction from position. The two last processes may be amplified; hence the number of times the operation of addition to position is performed is "multiplication," and the number of times the operation of subtraction from position is performed is "division." The number added to position is called in mathematical language the "multiplicand," the number of times of adding is called the "multiplier," and the result of the operations is called the "product." Inversely, what is to be subtracted from position is called the "dividend," and the number of times of subtracting is called the "divisor," and the number subtracted each time the

"quotient." Any departure from these fundamental ideas is a species of delusion or mental disease—because no physical processes correspond to the expressions or formulæ. Now, algebra abrogates these simple fundamental concepts, gets rid of the "multiplicand" and the "multiplier," and the conceptions attached to the words, and calls these "factors." Thus the mind gets into pure abstractions; the concept of the physical operation, with the idea of form which is embodied in practical arithmetic, is abolished.[1] From this fundamental error arises the notion that objects can be multiplied together, and the product can be quite foreign to the multiplicand; hence such an order of thought arises that an object, say, "one" apple, may be multiplied into another object, say, "one" pear, and the product one "unit" will be neither apple nor pear, but a metaphysical something absolutely foreign to both of the factors! Having made this fundamental error, algebra erects an enormous mental edifice upon an absolutely impossible or rotten foundation. Possibly algebra must be destroyed if we are to make progress. Arithmetic is sufficient; indeed, algebra cannot be worked until the symbols are converted into figures and worked, when true, by the foundation of mathematics—arithmetic.

These are algebraical concepts: something (an object, energy, force) can be subtracted from nothing! Some-

[1] Perhaps this obscure, but profoundly important, fundamental issue may be made clearer thus: Algebra, by getting rid of the concepts underlying the terms "multiplicand" and "multiplier," states that "a" multiplied into "b" is the same as "b" multiplied into "a." When the symbols are converted into concrete numbers this is only true when "a" and "b" have the same numerical values. For instance, 2 multiplied 6 "times" is quite a different operation to 6 multiplied 2 "times." Not only do the operations differ, but numbers operated on also differ.

thing can be subtracted from something half a time (an impossible concept) to produce two somethings! Something can be added to something half a time (an impossible concept), and can produce half a something! Nothing can be subtracted no times from nothing, and produce any number of somethings! Moreover, under certain mathematical conditions algebra says that addition is the same as subtraction! In fact, algebra, when made into concrete numbers, assumes the power to create matter, energy, and force, and equally to destroy the same. This is called an exact science! And it is this absurd order of thought which has been pressed upon physical science as the basis of deductive science! Moreover, algebra, when made into concrete numbers, states that something can be multiplied by or into itself. Fancy multiplying an orange by or into an orange to "produce" an orange to the second power, or to multiply this "product" into another orange to "produce" an orange to the third power—or the cube of an orange; or to multiply a line into a line to "produce" an area, or to multiply an area into a line to "produce" a cube! If the practical effort to do these things is made, it is found that the process is impossible. Consider the "square" of a second, or "what is rather absurdly called the square of the time—*i.e.*, the time multiplied by itself" (Sir Oliver Lodge); or consider the higher mathematics: "given three rigid spherical masses thrown into empty space with any initial motions whatever, and abandoned to gravity; to determine their subsequent motions.....is so complicated as to be beyond the reach of even modern mathematics. It is a famous problem, known as that of 'the three bodies,' but it has not been solved" (Sir Oliver Lodge). Can it be wondered that, with such

views, the mathematical physicist absolutely fails to interpret Nature?

The following parable strictly shows the attitude of the physicist to Nature: A certain physicist went to the sea shore—the tide was just beginning to rise. On the sand—midway between high-water mark and low-water mark—he drew with a stick a straight line parallel to the waves. He then admired his work, saying to himself: "This is very clever—it is a perfectly straight line; it is mathematically correct; it is quite rigid, and Nature must obey such an exact formula." So he pointed to the line, and said to the waves: "Thus far and no further shalt thou ascend"! This is an attempt to bind Nature to arbitrary rigid mathematical lines. The presumption and the folly to attempt to force Nature into rigid mathematical lines are deplorable. Nature abhors the rigid. Consider two apples; each may be regarded as an unit, and we may say: One apple equals another apple. This is mathematically correct, but it is not true, as no one has ever seen two apples exactly alike—or two natural objects alike. Nature abhors the rigid.

Physicists have endeavoured to reduce all natural phenomena on the earth to celestial physics, basing all upon Newton's grand law of gravitation. But, while the problem of "the three bodies" is unsolved, mathematicians cannot even interpret celestial physics by numbers alone. "In Astronomy we replace a planet by a so-called material particle—*i.e.*, a mathematical point associated with a suitable numerical co-efficient. All the properties of the body are here ignored except those of position and mass" (Lamb). The technical term "mass" (which is mathematical) is defined by a late distinguished physicist and mathematician as "hugger-

mugger," by which the student is "demoralized by having to swallow undigested a term of which neither he nor his teacher has a clear and distinct idea" (Fitzgerald). Now, there are many things on this earth which we can study and understand, if we eliminate the higher mathematics, and confine ourselves to the "queen of mathematics" (Gauss)—Arithmetic—for "We have, of course, in abstract science, a right to begin with any definition we choose"; but "our definitions must be consistent, and follow logically from the fundamental principles of arithmetic, otherwise we run the risk of sooner or later committing mistakes and encountering paradoxes" (Merz).[1] Now, these "fundamental principles" algebra not only ignores, but abrogates. This is the grand error.

One of the most remarkable of experiments negatory to the mathematical order of thought is to show that weight or mass is not a constant upon this earth. This can be easily proved. Put an equal weight into each pan of a balance and accurately counterpoise them; then select one weight and submit it to dry heat. As it becomes hot it becomes lighter, and this difference can be measured. As it becomes cold, or approaches the temperature of the weight which it counterpoised, it becomes heavier. Where does the mathematical term "mass" come in with this fact before us?[2] Again, put a small quantity of water into a shallow dish and counter-

[1] *A History of European Thought in the Nineteenth Century*, 1903. This valuable work gives 113 pages "On the Development of Mathematical Thought," and these pages show the vain efforts of the metaphysicians to attempt "the impossible."

[2] For the making of this and the following experiment the author is indebted to the well-known balance maker, Mr. Oertling. He informed the author that the heating of weights by filing so altered the value of each weight that getting the exact value was a tedious process. Even the heat from the hand will alter the value of weights.

poise the water in the balance. The water immediately alters in weight value—so quickly that, with a delicate balance, it takes an expert to obtain, at the instant, the exact value. This alteration is caused by the water molecules darting off the surface of the water, at the ordinary temperature of the air, the rate of motion varying with the temperature, and so lightening the mass of water in the basin. As each molecule darts off the water it expands in volume and becomes lighter. Now, this operation can be intensified, and when this is done the molecule becomes so large and light that it can be seen rising from the mass of water—the molecule is alive. It is profoundly interesting to see the water molecule darting up into the air, as if it were thrown by an invisible hand, in much the same way as a boy throws up a ball ; but, unlike the ball, it does not fall to the earth, or gravitate. This grand factor against the law of gravitation has never been properly recognised. It is, however, the key to all terrestrial physical phenomena. It is absolutely beyond the ken of the higher mathematics. So vast and powerful is this factor that our very existence depends upon it—all chemical reactions and " life " phenomena depend upon *the factor* (explained further on) which produces this reaction against gravitation, and which cannot be studied in celestial physics, nor by mathematics.

The narrowing action of trying to explain Nature by numerical values can be best illustrated by the following parable : A certain mathematical physicist became so saturated with the higher mathematics that he obtained numerical values for the furniture in his house. The table top had a numerical value, and also the legs of the table; so did the coal-scuttle, and even the coals in the

scuttle, as well as the chairs and other furniture. A friend of his—a Mr. Common-sense—called upon the physicist, and expressed great astonishment at what was being done. "See," said the physicist, "I have just obtained the numerical values of the tongs and of the poker." "What is gained by all these measurements?" said Mr. Common-sense. "I can understand measurements when you want to make or repeat things—say, tongs or pokers. Then measurements are of value." "Why," replied the physicist, "when I have obtained these values I can multiply them into each other and produce." "What," said Mr. Common-sense, "a shovel?—for I see you want this necessary article." "No," said the physicist; "I can produce a number"![1] "Cannot you see," replied Mr. Common-sense, "that with your numbers you lose the concept of form, and form is the essence of thought?" "Oh!" said the physicist, "you are a fool—get away." So Mr. Common-sense shrugged his shoulders and departed, leaving this old fossil measuring—he is still measuring. And this is the ancient that modern physical science holds up as an exact and perfect pattern—a sort of God to rule the universe!

Clerk Maxwell, the late eminent physicist, and one of the greatest of mathematicians, clearly exposed the fundamental error in these words :—

> "Mathematicians may flatter themselves that they possess new ideas which mere human language is as yet unable to express. Let them make the effort to express these ideas in appropriate words without the aid of symbols and if they succeed they will not only lay us laymen under a lasting

[1] Numbers are adjectives, and are senseless without the nouns. If a person says or writes "one," the answer comes "One what? Or if he in like manner expresses "good," the reply comes "What is good?" It is wonderful that physicists cannot see this important truism.

> obligation, but, we venture to say, they will find themselves very much enlightened during the process, and will even be doubtful whether the ideas, as expressed in symbols, had ever quite found their way out of the equations into their minds."

When Maxwell wrote this important confession he wrote under the name of "A Layman." It was an accident that revealed his name as the author; the quotation was never meant to see the light of day with Maxwell's name attached thereto. Still, what a confession it is of the physicist's ignorance!

We will make the issue still clearer. Physical fundamental units are all expressed in terms of units of length: one centimetre or one inch; units of mass: one gramme or one grain: and units of time: one second or one minute. These are all artificial units. Nature does not recognise them. We can multiply each independent unit. Thus, one gramme added to position ten times produce ten grammes to the position, and so on; or we can in the same way inversely divide (*i.e.*, subtract) the sum. This is common-sense mathematics. In this way Huxley showed the value of this order of thought when he said:—

> "'Mathematics may be compared to a mill of exquisite workmanship which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends on what you put in; and as the grandest mill in the world will not extract wheat-flour from peas-cods, so pages of formulæ will not get a definite result out of loose data'; and on another occasion he said that mathematics 'is that study which knows nothing of observation, nothing of induction, nothing of experiment, nothing of causation.' The former statement was endorsed by Lord Kelvin" (Merz. op. cit.).

We cannot multiply a centimetre into a gramme, or a gramme into a minute. Yet this is the fundamental

order of thought recognised by the physicist! Now, just as the physicist recognises definite units, so does Commerce recognise a definite unit in the coin called a sovereign. And the commercial man equates commodities as equal to a sovereign. The sovereign—the unit—will show the fallacy of algebra better than any other unit. We can add, say, ten sovereigns to a position, say, on a table, ten "times," and we "produce" one hundred sovereigns to the position. This is common-sense mathematics. Alter the concept. Place ten sovereigns on the table, and beside this ten place another ten sovereigns, and then try by any way conceivable to multiply (or otherwise) the ten sovereigns into the ten sovereigns to produce one hundred "units." What the latter term may mean no one knows; and this is applied algebra! Surely algebra must be abolished. Physicists think that when multiplying concrete numbers together the product gives definite ideas. The following shows the fallacy:—A man had assets £1,000 and liabilities £10. Call these concrete figures "factors," as the physicist does, then the numerical value of that man is 10.000. He is a man of means—solvent. Another man has assets £10 and liabilities £1,000, and his numerical value is also 10.000; but he is a bankrupt. Now, if these two men appealed to a judge on their numerical values alone, how could the judge distinguish the bankrupt from the man of means? Perhaps the best idea of true applied mathematics can be shown in that admirable and very beautiful system known in the commercial world as bookkeeping by double entry. Here we have the plus (+) in the debits and the minus (−) in the credits, and, as every debit equates a credit,

we have the fundamental concept in an algebraical equation. But here it is common-sense mathematics—*i.e.*, simple arithmetic. Algebra is not mentioned in the system. Now see how nature steps in and spoils the mathematics. The sovereign rarely permanently equates commodities; hence we have the rise and fall in prices. Values, because of the laws of supply and demand, are always differing. Now, if physicists will throw aside their metaphysical order of thought—for, says Sir Oliver Lodge, "few indeed are the men who can handle it (*i.e.*, the higher mathematics) safely and satisfactorily, and none without continual appeals to experiment for verification.....For observe that the mathematical study of Nature, the discovery of truth with a piece of paper and a pen, has a perilous similarity at first sight to the straw-thrashing subtleties of the Greeks, whose methods of investigating Nature by discussing the meaning of words and the usage of language and the necessities of thought had proved to be so futile and unproductive" —if the physicist, we repeat, will adopt common-sense mathematics and throw aside the metaphysical, and use mathematics as the chemist does, or as the engineer and the carpenter do, or the commercial man does, then the physicist and the mathematician will no longer be "alike in trouble about their souls" (Lamb).

A concrete example will serve us. Physicists recognise a law called "Boyle's law." It states that pressure on gases can be multiplied into the volume which the pressure produces. Formulate this idea in any units we may select, say the pressure of one pound weight into the value of one measured pint, and try to physically multiply these two units to produce one unit, and the concept is found to be physically impossible. But if we

alter the idea into common-sense mathematics, then we obtain data—natural equations—of great value. Thus equate the volumes in terms of pressure in this way :—

$$\begin{aligned} p &=^{1} v \\ p' &= v' \\ p'' &= v'' \end{aligned}$$

and then with common-sense mathematics the equations will always be true, providing the external temperature and the air pressure are the same. This is all that we require for practical purposes—that is to say, a formula by which we can repeat operations and get certain definite results. This is quite a different concept from that of p (pressure) multiplied into v (volume) to produce a "constant" which is only a number without meaning. Now, we can understand the parable of the physicist at the sea-shore. The physicist vainly wants Nature to be subordinate to the higher mathematics. What a futile and egotistical error! Moreover, suppose the formula were possible, it cannot be true, because, if it were true, then the same formula which liquefies carbon-dioxide will also liquefy hydrogen. This is found not to be true in practice.

The following, from the writer's book, *What is Heat and What is Electricity?*[2] fully shows the absurdity of mathematical concepts :—

"Everyone knows that matter expands when it is said to be heated, the only exception being when there is a change of state in the molecule, such as during the process of crystallisation. Now, this increase in dimensions is called by the physicist the 'co-efficient of expansion.' We will give two illustrations of this expansion from two well-known text-books.

[1] The equation symbol (=) is here used in the same sense as the following: 12 pence = 6 oranges.

[2] Published in 1894.

"Fig. 1 is from Garnett's *Elementary Treatise on Heat;* Fig. 2 from Deschanel's *Natural Philosophy*, Part II.—Heat. The first thing which immediately strikes the reader is, that there are here figured two expressions of one fact, quite different—both cannot be right.

"In the first case, the idea is that when a body of a certain temperature—*i.e.*, a certain volume, expands, Nature picks up volumes of matter—slabs, as it were, of the same matter—three pieces, and places them on three sides of a cube. Then, in order to make the increased volume a larger cube, the mathematician supposes that Nature puts into the vacant edges three long rectangular pieces to fill up those spaces; and then he supposes

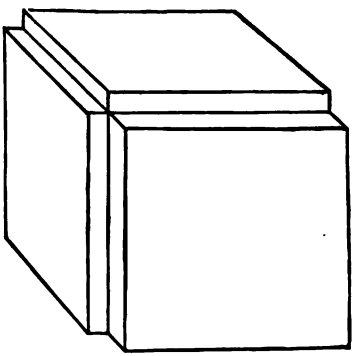

FIG. 1.

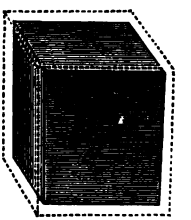

FIG. 2.

that Nature adds finally a small cube to the corner. This is a pure geometrical concept, but what a monstrosity the idea is! We will describe the process in the words of the physicist:—

"'Most substances, except crystals, expand equally in all directions when heated. Imagine a cubic block, the length of whose edge is 1 foot; its volume will then be 1 cubic foot. Now, suppose that on raising its temperature 1° C., the length of its edge becomes $1 + a$ feet, so a is its co-efficient of linear expansion.[1]

[1] It should be here remarked, "linear expansion" is purely a metaphysical concept, because no matter can have length without breadth and depth. In Nature, matter acquires cubical expansion when it is heated; but it is not the expansion described above by the geometrician.

Then its volume is $1+3a+3a^2+a^3$ cubic feet,[1] and the increment of its volume is $3a+3a^2+a^3$ cubic feet. The ratio of this to the original volume, viz., one cubic foot, is $3a+3a^2+a^3$, which expression is therefore the co-efficient of cubic expansion. Now, a is, in general, very small; hence a^2 and *(à fortiori)* a^3 may be neglected in comparison with a. We have, then, for the co-efficient of cubic expansion $3a$, or *the co-efficient of cubic expansion is three times the co-efficient of linear expansion* for the same substance. .....The effect of neglecting the terms involving a^2 and a^3 may be illustrated by taking a cube of 10 centimetres side, three plates each 10 centimetres square and 1 centimetre thick, three strips each 10 centimetres long and 1 centimetre square, and a cubic centimetre. Placed together, these will build up a cube of 11 centimetres edge. If we neglect the three strips and the cubic centimetre, our enlarged cube is incomplete at the edges' (Fig. 1), 'and this is equivalent to neglecting $3a^2$ and a^3 in the above expression.'

"'Or we may employ the following illustration: Take a cube of wood or other material of one foot edge, and let this represent the unit of volume. Suppose a to be .01. Then a piece of pasteboard of one foot square and .01 ft. thick will contain a units of volume, while its thickness will be a units of length. Take three such plates, the sum of whose volumes is $3a$,[2] and apply them to the three faces of the cube which meet in a point. Now, take three rectangular strips of pasteboard a foot long and .01 ft. square. The volume of each of these is a^2,[3] and the volume of the three together is $3a^2$. If these strips be laid in the grooves formed by the edges of the plates, there will only be required a cube of .01 ft. side and volume a^3 in order to complete a cube of 1.01, or $1 + a$ feet edge. The whole increment in volume of the one foot cube

[1] This expression, when put into common-sense language, means: To a line is added a line multiplied three times, to this sum is added an area multiplied three times, and to this sum is added a cube! Let the reader try to realise this nonsense, and he will find that his mind fails. What is the total sum of the additions?

[2] It will be noticed here $3a$ is a linear expansion, $3a^2$ is a surface expression, while in the illustration both are objects of cubical dimensions.

[3] The *volume* of an object described as of superficial area only is a contradiction of terms.

is the volume of the three plates together with that of the three strips and the small cube, or $3a + 3a^2 + a^3$. If we take the co-efficient of cubic expansion to be three times that of linear expansion—that is, take into account the plates only—we neglect the strips and the little cube; but even when the linear expansion is so great as .01 of the original length, the error so introduced is very little more that one per cent.'[1]

"Now Deschanel, seeing no doubt the geometrical error as illustrated in Fig. 1, substitutes Fig. 2, the dotted lines of which really represent the true co-efficient of expansion; but here comes the difficulty, and this is very important to observe—the notion of the mathematician is to try to force natural phenomena to follow rigid lines, and Nature abhors the idea—in fact, will not have it. It would seem the mathematical mind cannot express the co-efficient of expansion as Nature performs the act, for *Deschanel is driven to the same formula as Garnett gives to explain his diagram!* He substitutes only the letter l for the letter a. Thus he expresses the reaction of the addition of Heat to the solid in these words:—

"'If a cube, whose edge is the unit length, expands equally in all directions, the length of each edge will become $1 + l$, where l is the linear expansion; and the volume of the cube will become $(1 + l)^3$ or $1 + 3l + 3l^2 + l^3$. In the case of the thermal expansion of solid bodies l is always very small, so that l^2 and l^3 can be neglected, and the expansion of volume is therefore $3l$; that is to say, the *cubical expansion is three times the linear expansion.* This is illustrated geometrically by Fig. 2, which represents a unit cube with a plate of thickness l, and therefore of volume l applied to each of three faces; the total volume added being therefore $3l$.'[2]

"Now, notice the error of expression, Fig. 2 does not represent the increase of volume by '*three faces*,' but by six faces!

"Thus the idea given by the mathematician, in the case of expansion of matter by increase of temperature, is the *addition* of matter to matter. This, in the sense in which it is used, everyone knows is not true.

[1] *Elementary Treatise on Heat*, by William Garnett, M.A. (5th edition), 1889, p. 66.

[2] *Elementary Treatise on Natural Philosophy*, Part II.—Heat, by A. P. Deschanel. Edited by J. D. Everett, M.A., etc. (11th edition), 1889, p. 277.

"Again, let us take the broad notion thus expressed by the physicist, and see how utterly unnatural it is. Railway engineers, in order to allow for expansion by increase of temperature, place the rails a short distance apart. Now, the concept expressed above by the physicist is, that in the hot weather Nature picks up some steel, places a piece on one end of the rail and a strip on one side and a strip on the top. This would mean that we should see, in cold weather, pieces of steel lying beside the rails, as a sort of great-coat of *always variable thicknesses*, which the rails have cast off because the weather is cold, and which they are ready to put on when the weather is hot. Is it possible to have a clearer illustration of the unreasonableness of mathematical concepts? True, such ideas have value for utilitarian or commercial purposes; but they are absolutely unreal, and should be regarded as such. Can we wonder, therefore, that the physicist, approaching Nature with such fundamental notions, fails to penetrate the truths of Nature?"

Now, let us put the formula into common-sense terms, and see how terse and clear the concept becomes: Select a cube of any material, say, iron, Fig. 2. Bore a hole into the top to fit a thermometer, so that the bulb is in the centre of the cube. Let the cube be heated to any temperature, and we get natural equations, and the arithmetic employed is of the simplest description, and, still more important, the calculation is without any neglected product. The equations may be expressed thus:—

Temp.		Volume.
1°	=	1 vol.
$20^{\circ\prime}$	=	$1'$
$100^{\circ\prime\prime}$	=	$1''$

and so on. But the formula will only hold good for the material used in the cube. There is no common mathematical law of expansion. And, indeed, the above formula is qualified by the temperature of the surrounding atmosphere when cooling in air. It is, however, good enough for practical purposes.

By making tables showing the various reactions in natural equations we obtain what Maxwell suggests is of the highest value—namely, a concept which gives "a lasting obligation" to the layman; moreover, this common-sense information will not only be of great value to that very large class—the educated laymen—but will be of great value to the whole community. More than this, it will relieve the educator and the pupil from a mental strain which ruins the intelligence of both—for bear in mind the words of Sir O. Lodge: "Few, indeed, are the men who can handle it (the higher mathematics) safely and satisfactorily, and none without continual appeals to experiment for verification." The latter confession is profoundly important, and shows that experiment is the only process necessary. Do we go too far, then, when we say algebra must be abolished? To substitute algebra for experiment and tabulated results is like a man wishing to go from Liverpool Street Station to St. Pancras Station, London, who takes the train to the mathematical centre—Cambridge—and then, *viâ* the Midland Railway, returns to St. Pancras!

But does the physicist want the result we are suggesting? It is feared not. What the physicist seems to aim at is to create a profession with its trade secrets or mysteries in order to hide Nature's processes from the educated community. If this is so, then does not the physicist render himself liable to the accusation of charlatanism—a charlatanism of the worst order?

The true mathematical order of thought—*i.e.*, simple arithmetic—is not only common-sense, but it is that form of mathematics which the practical man will

always use. But besides that which may be called the mere utilitarian or commercial study of Nature, the study of natural phenomena has a much higher value for humanity, and this is very important. The statistical and numerical values in natural phenomena, while they have practical values, are secondary and quite artificial. Clerk Maxwell clearly saw this when he truly said: "The human mind is seldom satisfied, and is certainly never exercising its highest functions, when it is doing the work of a calculating machine."

Moreover, the exclusive use of the higher mathematics gives rise to the most contradictory or opposite ideas—both of which cannot be true. Consider the two generic terms "conservation of energy" and "dissipation of energy." This means that energy is always maintained, and then *per contra* it is always disappearing. This is a concept arising from the higher mathematics; but what an absurdity!

Or take another view of the absurdity of ideas founded upon the higher mathematics. Suppose a surgeon called in to perform an urgent operation. How would it assist him to commence by getting the numerical value of a variable—a muscle—and afterwards the numerical value of a constant—a bone—and then multiplying together these two "factors" before he could conceive how to perform his operation. Professor Lamb has shown the absurdity of this concept in these words:—

> "A traveller who refuses to pass over a bridge until he has personally tested the soundness of every part of it is not likely to go very far; something must be risked, even in Mathematics."

Now, we contend, firstly, that the study of the

higher mathematics is a grand fundamental error—that it precludes the mind by its abstractions, or narrowing processes, from taking a large view of Nature, and on this large view of Nature man's prospective happiness and prosperity depend; secondly, that this large view, and this alone, will mitigate human misery; and that this large view is only to be obtained by experiment[1] and the closest study of Nature.

Nature is so liberal that if we approach her in a proper spirit she reveals her secrets to us in the freest way. And this is what she teaches by experiment:—

All matter, organic and inorganic, is built up of extremely minute indestructible objects—called sub-atoms—so minute as to be quite beyond our ken as to dimensions; but these objects have dimensions. If we can permit ourselves to rely upon our innate conceptions, coupled with the observations of the eye, and by reactions which can be experimentally proved, then these objects are always solid spheres of constant dimensions—that is, of the same species. Every specific class or species of sub-atom, such as the oxygen, hydrogen, nitrogen sub-atoms, are constant in dimensions; but the dimensions of each class of sub-atom differ in volume from the others; for instance, a sub-atom of oxygen is different in dimensions from the sub-atom of hydrogen, also there is a differential attracting power for each species of sub-atoms. This latter is the foundation of gravitation.

These sub-atoms group themselves by their mutual attraction and form spheres, and these spheres, always of the same species of sub-atoms, make the "chemist's

[1] An experiment is only an operation in Nature made on a small scale, so that it can be easily studied.

atom." When the grouping is of different species of sub-atoms then is formed the "chemist's molecule." Thus a molecule of water consists of two groups of hydrogen sub-atoms and one group of oxogen sub-atoms, which form a sphere—the water molecule. These chemists' atoms and molecules are not rigid, but increase and decrease in volume, just like a soap bubble, by the absorption of a still vastly finer atom which acts against gravity or antigravitates. Here, again, we understand the parable of the physicist at the sea-shore, for the mathematical physicist wants to abrogate the teaching of Nature, and to make the chemist's "atom" or "molecule" an object of constant volume and form. It is very wonderful and beautiful to see the motions of the atoms or molecules (either term will suit) of the gases of the elements bromine, chlorine, and iodine. These objects, having colour, can be examined in air and can be seen. They become lighter and rise, and then denser and they fall—the two reactions forming most interesting irregular swirls, a motion which is entirely beyond mathematical concepts. Also it is equally wonderful and interesting to see the molecules of water or other liquids in the vaporous or gaseous condition giving a like order of motions.[1] This is what can be seen if physicists will only take the trouble to look. But like the opponents of truth in old time, as when Galileo requested the then orthodox to look at the real things in the heavens, so the believers in meta-

[1] The author is willing to send particulars of a *few* of these important fundamental experiments to anyone interested in them who may make application to him at "Glenlea," 109, Thurlow Park Road, West Dulwich, London, S.E. Not only are the experiments very beautiful and instructive, but they are very simple and easy to repeat.

physics—the present physicists—reply that this way of understanding Nature is not the rigid view of mathematics, and therefore such an investigation must not be entertained!

Now, when gaseous matter—"chemists' atoms" or "molecules"—becomes solid, often, but not always, the spheres built up of sub-atoms become angular, and then we have the crystal.

More than this, the real factor which causes the differentiation of structure is a vastly smaller or finer atom than the sub-atom, which we may call an electron or a corpuscle, or the better term, we think, an atom of Ether. Do not let us worry about terms; let us get the concepts lying behind the terms. We have too many terms already. Now, in mass this Ether, if properly illuminated, can be seen as distinctly as water can be seen coming out of a water tap. It can be seen exuding out of and rising from a heated weight, and it can be seen exuding out of, and rising from a lead carrying the electric current; also it can be seen coming out of the human body. And this fluid, when it attacks a thermopile or a thermo-couple, or even a simple wire, if properly prepared, becomes the electric current, and it turns the needle of the Galvanometer. This fact, and other facts, the writer experimentally showed and published over ten years ago.[1] The numerous fundamental experiments nearly all tell one grand fundamental tale, and this is the result of appealing direct to Nature in the proper spirit, and not attempting to "boss" Nature by metaphysical concepts. And the tale is: We live in

[1] See *What is Heat and What is Electricity?* (London, Chapman and Hall.)

an ocean of Ether the same as fish live in a liquid, and this Ether occupies in a differential way the interior of "chemists' atoms" and "molecules," and this Ether is *the factor* in all life and all chemical reactions. *It is omnipotent and omnipresent.* Take it away from matter, and matter, as it were, sleeps. There is neither building up nor falling down in molecular complexity. But matter does not die, for when Ether is again brought to matter the inherent molecular activities again arise, and these inherent activities are the energies of the chemists' and physicists' atoms and molecules. The knowledge of these facts should be the first principle of education.

Now, we can understand how dead animals and vegetables are preserved by so-called refrigeration. We simply extract and keep out the Ether, and this is called lowering of temperature, or cold.

All these concepts are quite beyond the notions of the mathematician.

It is very wonderful how the physicist, through his metaphysical or mathematical reasoning, is utterly oblivious to the error in logic in his fundamental deductions. Thus there is not a physicist but will tell you that when he reduces the volume of a gas he heats or raises the temperature of the gas. Now, if this were true, liquid air should be intensely hot, for it is only gaseous atoms reduced in volume to about one-eight-hundredth of its volume in the gaseous condition at ordinary temperature; whereas, instead of being intensely hot, it is one of the coldest substances known! And the assertion is hazarded that when this fundamental error is corrected, as it must be, then the physicist will have made a discovery—a mental revolution—which

will transcend in importance the all-important discovery that the sun is the centre of the solar system.

All the mathematical nonsense arises from what is taught by the school-masters. Here is where the great future mental revolution must arise. The individual who most pressingly needs educating is the school-master.

Let us raise the curtain of ignorance, and peep into the future. The picture may not be exact, but it will be nearly true. We are approaching the time when the pupil will, after he has learnt reading, writing, and arithmetic, be taught Natural Philosophy in lieu of the nonsense he is now crammed with, and which he does his level best to forget directly he leaves school. Now, when he leaves school he finds that probably at least one-half he has learned is not only of no practical use, but is misleading; hence a natural contempt for his late teachers arises. The process of teaching nonsense or error is equally wearisome to teacher as to scholar, and the present-day intelligent teacher knows that what he is doing is humbugging his pupils; hence he has a natural contempt for himself.

The teaching of Natural Philosophy—which only means the close study of Nature in her varied aspects—is not only a pleasure for the teacher and the pupils, but after the school life is over, the faculties of the pupil are strengthened in what he has been taught. We must recollect that every invention, every commercial success, is based upon natural knowledge. How little is this taught in schools! Children are not taught to reason, but to repeat like parrots. To read that all-important Bible—not written by human hands—the history of the rocks, as interpreted by geological science; to know one's own constitution, as interpreted

by physiological science; to know our external and internal conditions, as interpreted by physical science—these are matters which are the foundation of education. But they are rarely taught. They are beginning to be taught; but they are also being taught—at least, as far as physics go—through the instrument we have so thoroughly condemned — metaphysical mathematics. More than this, the very attitude of the teacher must alter. He must no longer be the teacher *ex cathedra* who crams the pupil, but the co-worker with the pupil—simply a leader—and then there will be no longer the necessity for examinations to prove the best-crammed pupil and to make a prig of him, neither will there a necessity of prizes to stimulate the pupil in being crammed. These alterations are coming very quickly, mainly from the United States, where education is so far in advance of the education in our country as to command the anxious thought of the best teachers.[1]

Then, and then only, shall we ascend to a higher mental region. Nature then will appear to man so different. The air, the water, the mountains, the valleys—indeed, the world as a whole—all will have new values of interest, and a spirit of admiration of Nature will enter the mind of the human being. In this education the microscope and the telescope will largely come into use, for when the faculties are expanded by the use of these instruments, then, indeed, man recognises the truth and

> "Finds tongues in trees, books in the running brooks,
> Sermons in stones, and good in everything."

[1] See the reports of the Mosely Education Commission to the United States of America.

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[*Continued on third page of cover.*